Finding the Drift Shadow in Nature

Timothy J. Kneafsey, Teamrat Ghezzehei, Grace W. Su, and Patrick F. Dobson
Contact: Timothy J. Kneafsey, 510/486-4414

RESEARCH OBJECTIVES

The drift shadow is a region (within the unsaturated zone) of limited water flow and chemical transport beneath an underground opening, such as a cave or mined tunnel. This region is partially sheltered from downward-percolating water by the existence of the opening and preserved because capillarity is not strong enough to immediately draw the water laterally back under the opening (see Figure 1). Because the drift shadow is sheltered, there is less water there, and the water present moves slower than in other regions; thus, transport rates there are reduced. The drift shadow has not been observed in nature, but its existence has been predicted by analytical and numerical models of flow and transport through unsaturated media. Our research objective is to demonstrate the presence of the drift shadow in nature.

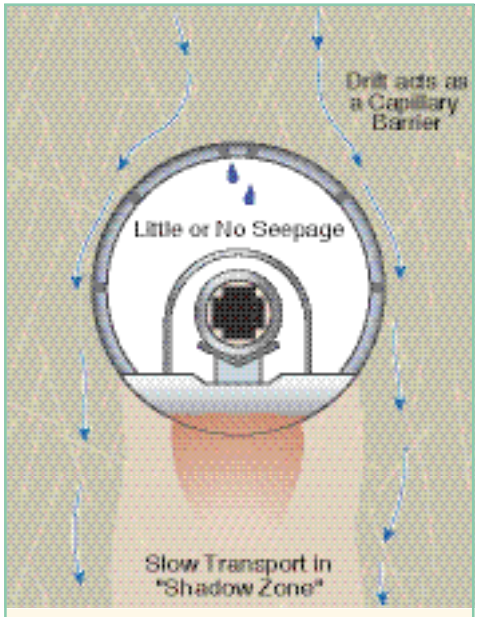

Figure 1. Conceptual model of flow around a drift showing the capillary barrier at the drift crown, and the drift shadow below the drift.

APPROACH

We will use passive and active tests at a field site to demonstrate the drift shadow presence. Passive tests will include making measurements of water potential in the rock surrounding a drift, analyzing geochemical signals caused by the drift shadow, and using ground-penetrating radar and neutron logging to measure the water content of rock surrounding the drift. Active tests could include introducing water with or without tracers above an existing drift, and looking for the presence and concentration of the tracer at locations around the drift. The field measurements will be compared with a detailed site-specific model, to build confidence in the ability to model unsaturated flow.

ACCOMPLISHMENTS

Extensive modeling of the drift shadow has been performed to understand the theoretical definition and drift shadow extent for various sets of conditions. The results of this modeling effort have led to refined site-selection criteria. Many potential analogue sites, including caves, mines, and concrete pads, have been investigated and evaluated, and we have tentatively selected the Hazel-Atlas sand mine in Antioch, California, a mine that has been closed since the 1940s. Preliminary cores have been obtained and analyzed for moisture. Chemical and mineralogical analyses and measurements to obtain hydrological parameters are in progress.

SIGNIFICANCE OF FINDINGS

Demonstration of the presence of a predicted drift shadow will provide another line of evidence to build confidence in the theory of flow and transport in unsaturated media and its numerical extension. In addition, it will allow the consideration of significantly reduced rates of transport from waste emplacement drifts at the proposed high-level nuclear waste repository at Yucca Mountain, Nevada, where waste canisters are expected to be placed in near-horizontal drifts in the unsaturated zone.

RELATED PUBLICATION

Houseworth, J.E., S.A. Finsterle, and G.S. Bodvarsson, Flow and transport in the drift shadow in a dual-continuum model. Journal of Contaminant Hydrology, 62–63, 133–156, 2003. Berkeley Lab Report LBNL-49868.

ACKNOWLEDGMENTS

This work was supported by the Director, Office of Civilian Radioactive Waste Management, Office of Science and Technology and International, of the U.S. Department of Energy under Contract No. DE-AC03-76SF00098.